Simulation plots for Pre-CDR

Jin Huang (BNL)

Also for Megan Connors and Stefan Bathe

Pre-CDR plot summary

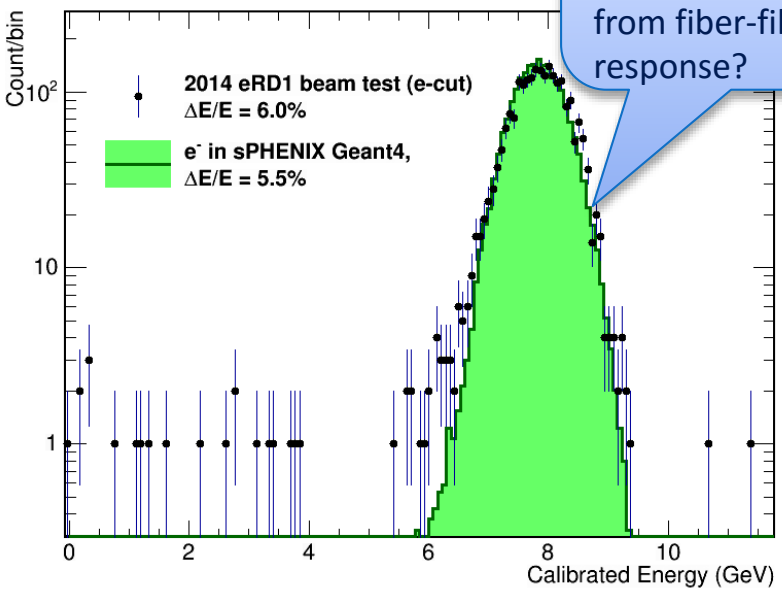
- Single particle (e/mu/pi/p/gamma/pi0)
  - Line shapes [Jin] <- Done
  - Sampling fraction [Jin]<- Done
  - Linearity [Jin] <- Done
  - Energy resolution [Jin] <- Done
  - Lateral extension [Jin] <- Done : Use old plots
  - Dynamic range [Jin] <- Done
- Au+Au HIJING embedded
  - Underlying event energy and fluctuation [Jin]
    <- Done
  - Rejection vs efficiency for electrons [Jin]
    <- Fixing track proj. tools,
    <- pending embedding production and analysis tools
  - Photon resolution [Stefan and Megan]
    <- Promising PHENIX Clusterizer, need embedding
- EM energy trigger performance
  - Turn-on curve [Jin] <- Done

Software tools

- Software: in analysis repository
  - https://github.com/sPHENIX-Collaboration/analysis/tree/master/EMCal-analysis
  - Analysis module : EMCal-analysis/EMCalAna
  - Plot macros: EMCal-analysis/macro
- Mike's evaluator tool are very useful in trace between truth and reco track/towers
- Fun4All analysis module to build my ntuple of emcal focused analysis

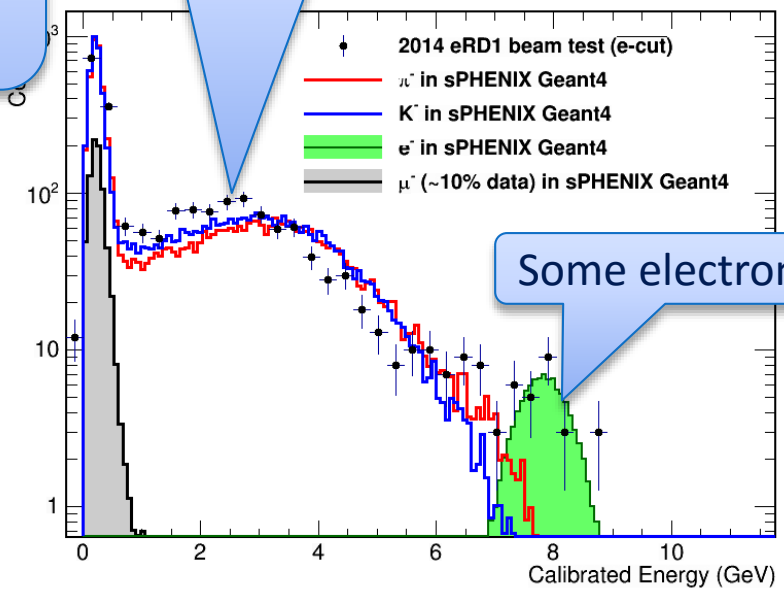
Test beam comparison:
8 GeV beams shower in Geant4 VS data

Very good matching in line shape.
Data: slightly more fluctuation (<10% rel.) from fiber-fiber response?



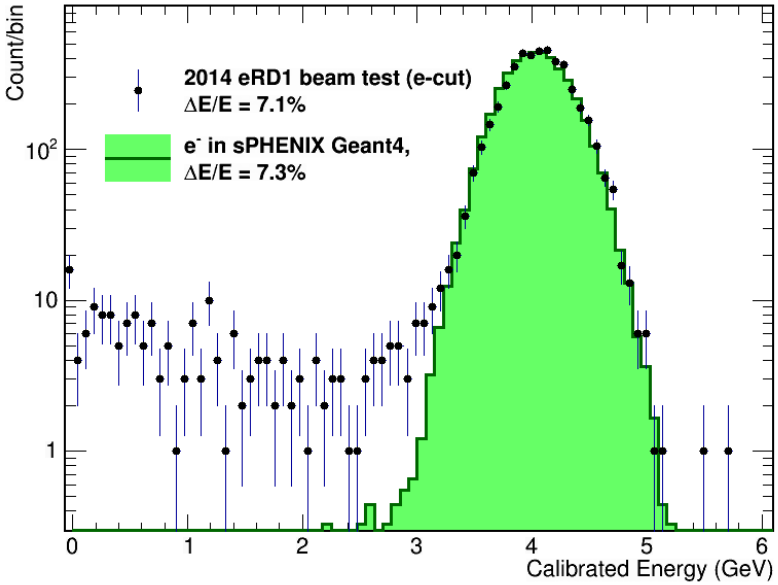
Less response in data?
Proton component?

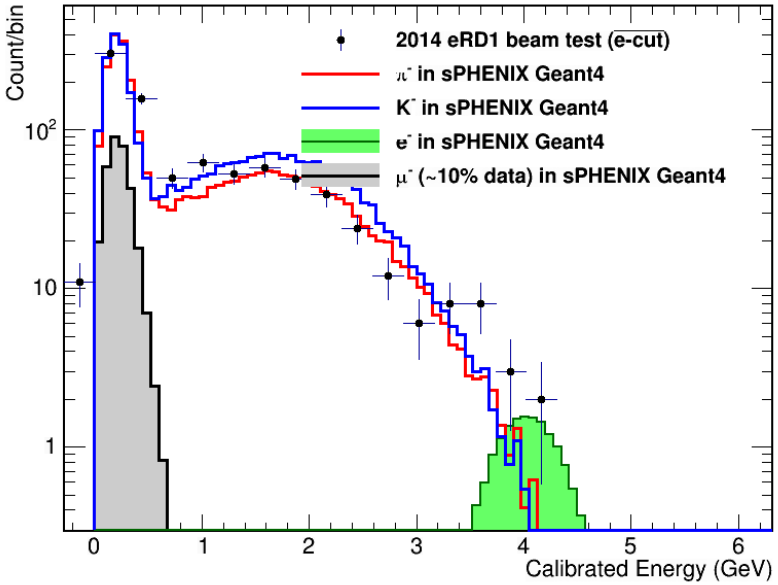
Some electron left



Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

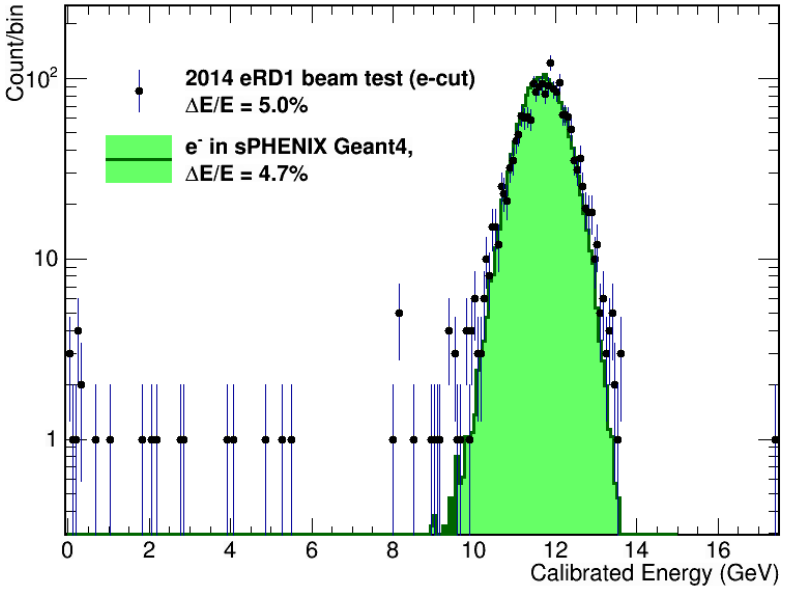
Test beam comparison:
4.12 GeV/c beams shower in Geant4 VS data

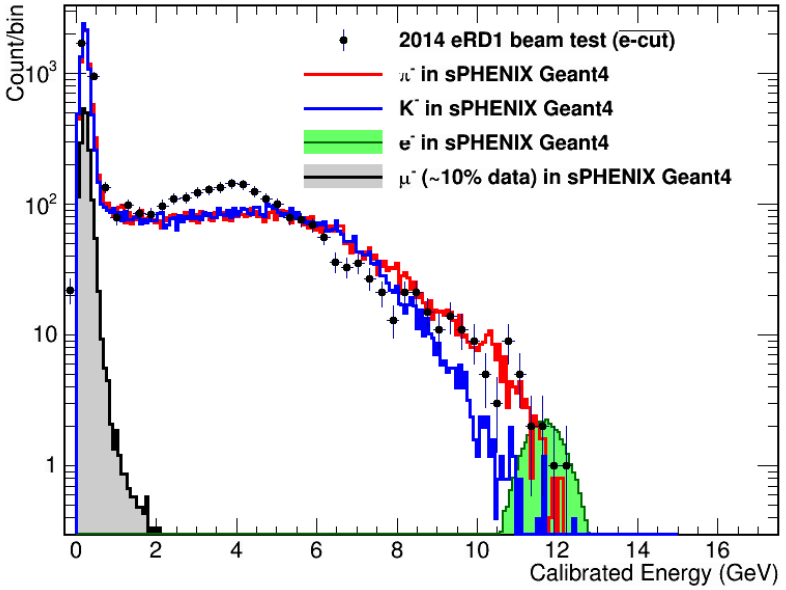




Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

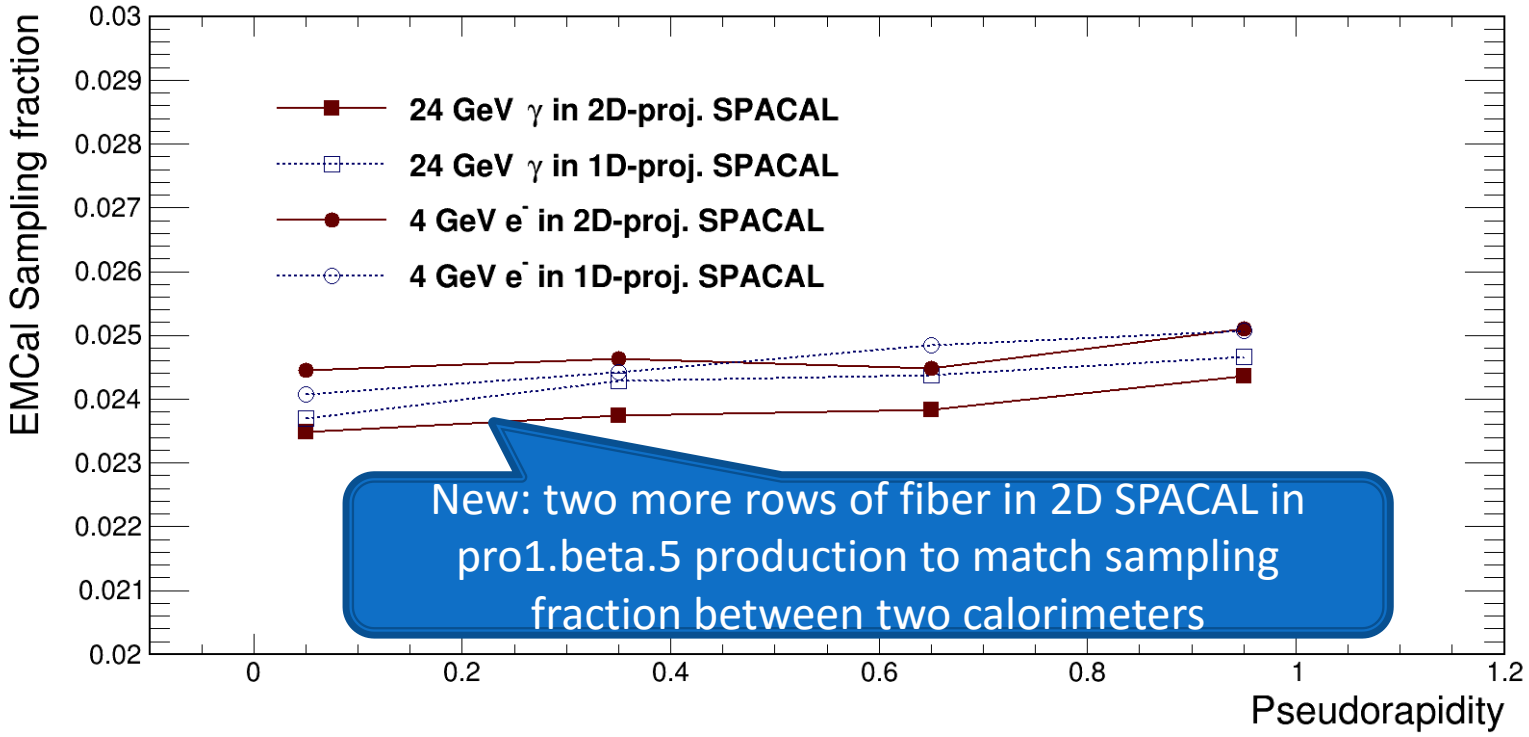
Test beam comparison:
12 GeV/c beams shower in Geant4 VS data





Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

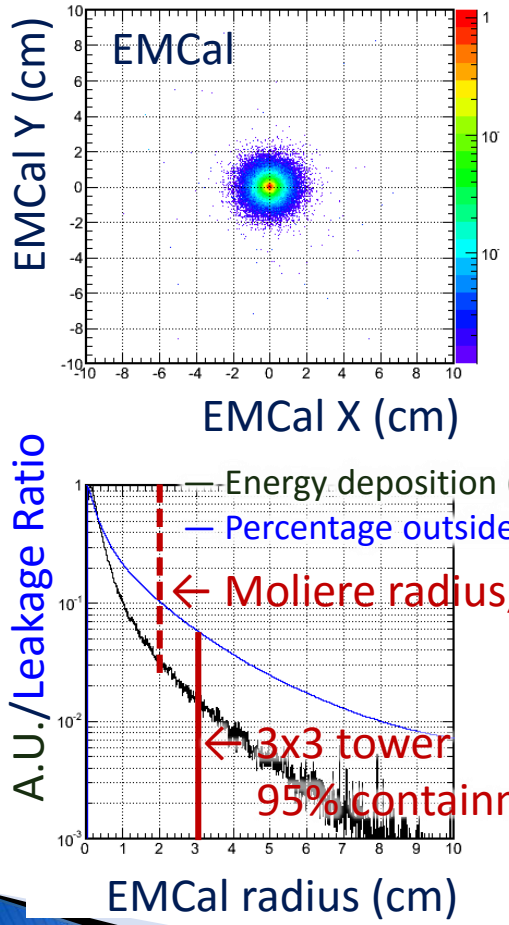
Sampling Fraction



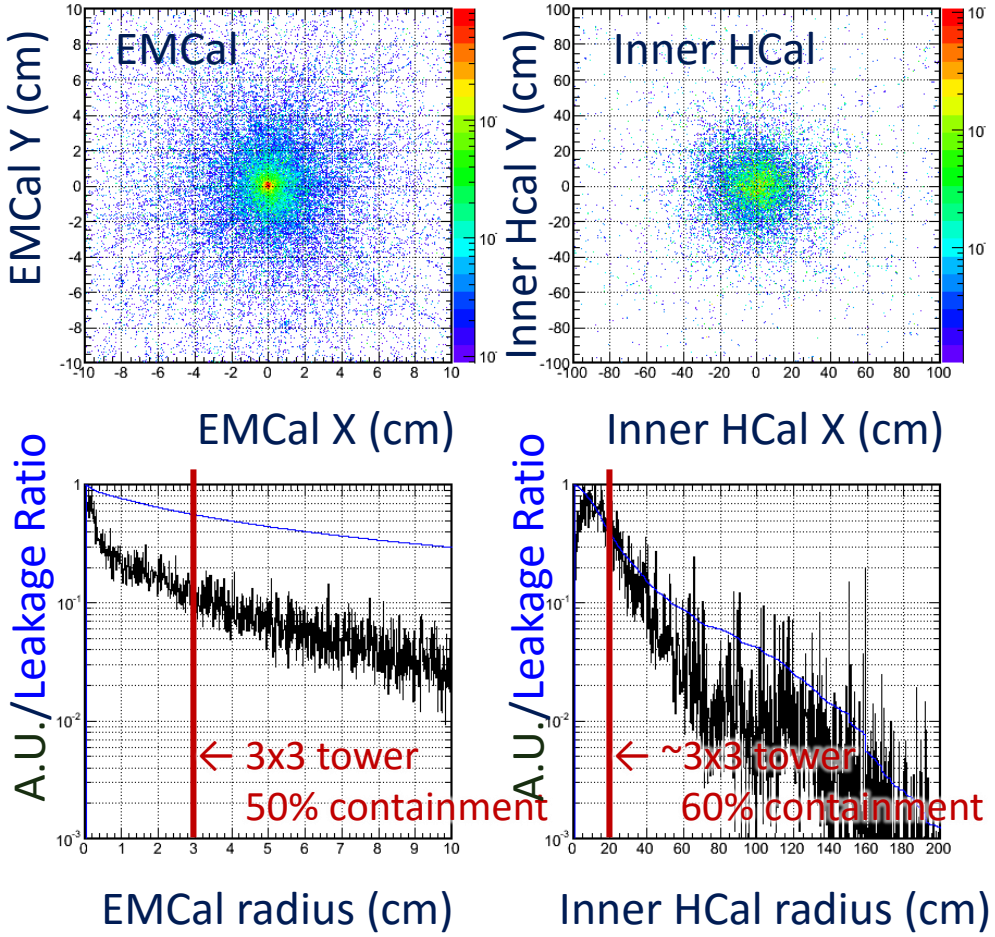
/direct/phenix+sim02/phnxreco/ePHENIX/jinhuang/sPHENIX_work/single_particle/DrawEcal_DrawSF.pdf

Lateral extension of shower

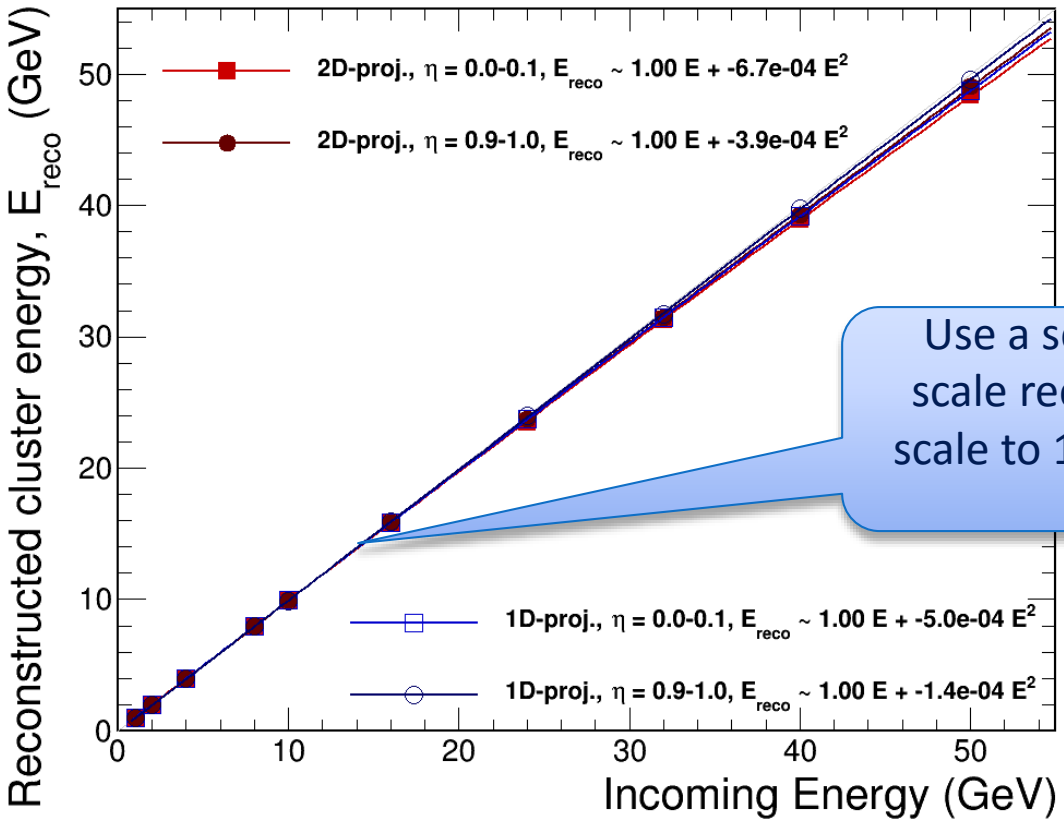
4 GeV Electrons



4 GeV Pions, that **passed E/p electron-ID cut**



Linearality – double checking



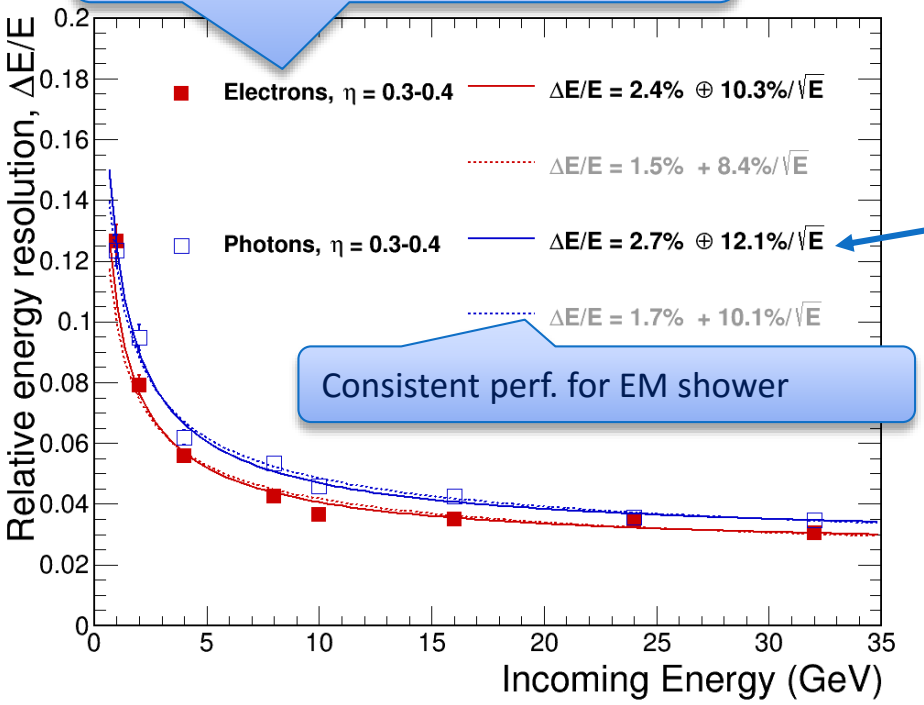
Use a scale correction to scale reconstructed linear scale to 1 individual at each eta region

Energy resolution VS test beam

Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe/32MeV), Graph Clusterizer

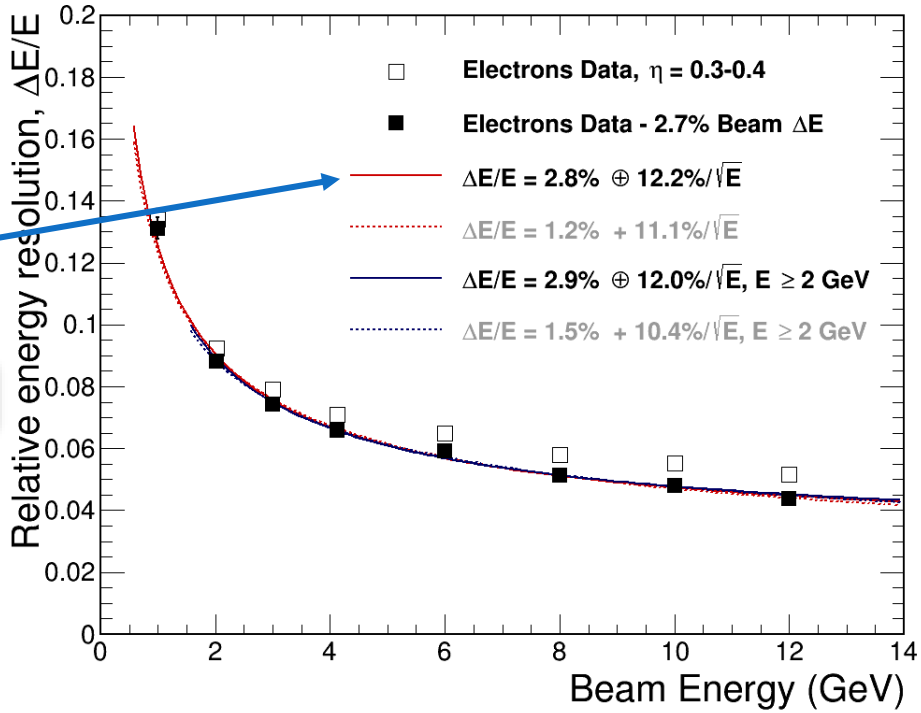
sPHENIX simulation,
1D projective EMCal only, full B

1GeV electron is B-bended by 0.45 rad
→ higher SF. and performance



Consistent perf. for EM shower

EIC RD1 study
FermiLab beam tests, 1D projective EMCal



Note difference in range of X-axis

Energy resolution inspections

Simulated on SPACAL without VTX and in full magnetic field

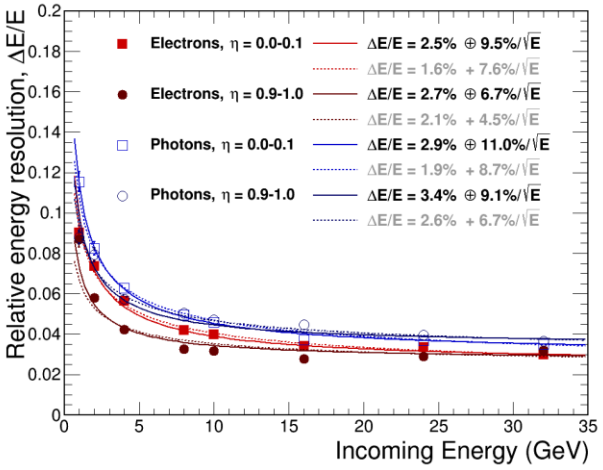
- 1GeV electron is bended by 0.45 rad → performance ~ photon w/ eta of 0.45 and view higher SF.
- **For EIC, Resolution ~< 12%/√E for electrons after magnetic field bending**
- **For sPHENIX, Resolution ~< 14%/√E for direct photons**

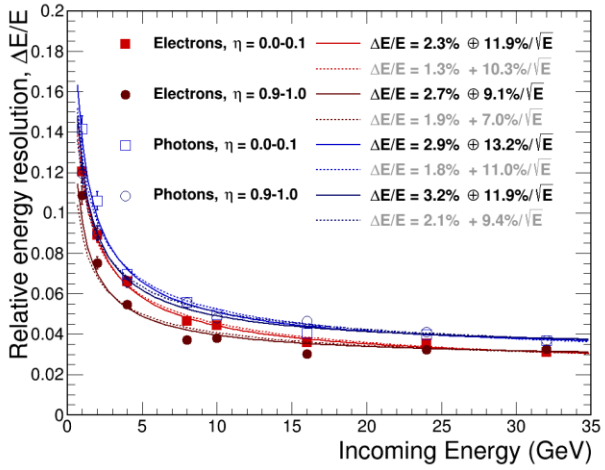
Sampling fluctuation
- 11%/√E for γ
- 9.5%/√E for e^- w/ B

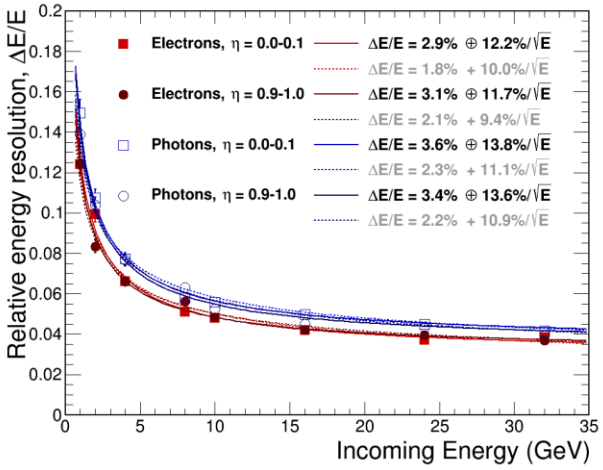
+ readout / clustering
- 13.2%/√E for γ
- 11.9%/√E for e^- w/ B

+ 2D SPACAL
- 13.8%/√E for γ
- 12.2%/√E for e^- w/ B

+ Silicon detector
- 13.5%/√E for γ







1D SPACAL, No SVX, Sum all tower

No photo-electron fluctuation/pedestal noise

1D SPACAL, No SVX,

Pedestal noise (2ADC), photon fluctuation (500e/GeV)

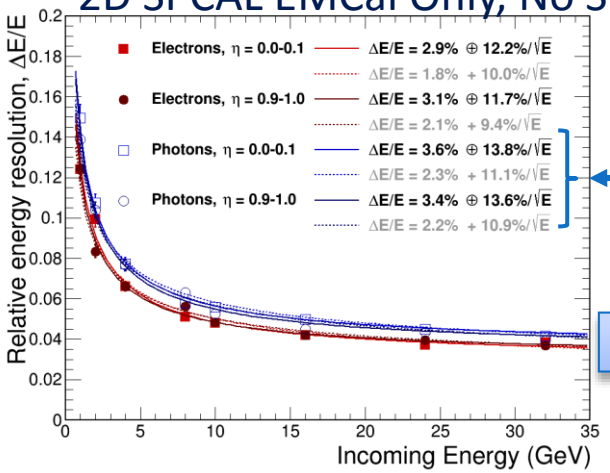
2D SPACAL, No SVX,

Pedestal noise (2ADC), photon fluctuation (500e/GeV)

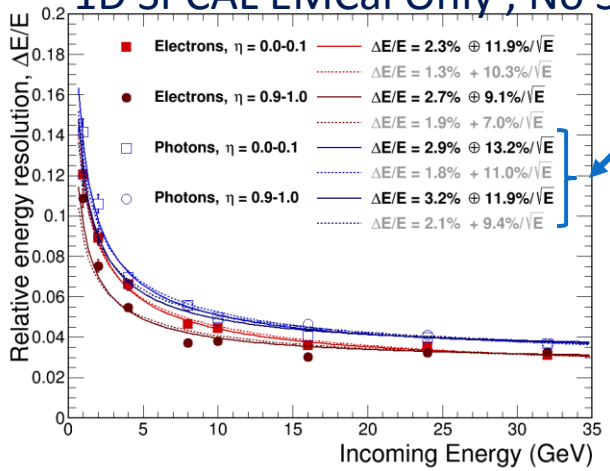
Energy resolution for full detector

Full detector Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe), Graph clusterizer

2D SPCAL EMCal Only, No SVX

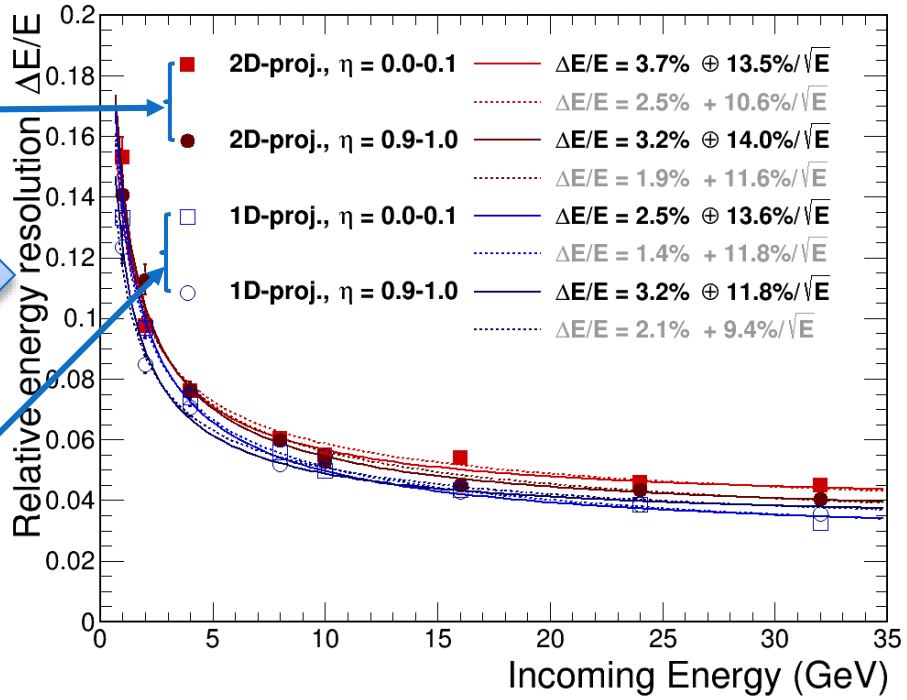


1D SPCAL EMCal Only , No SVX



+SVX

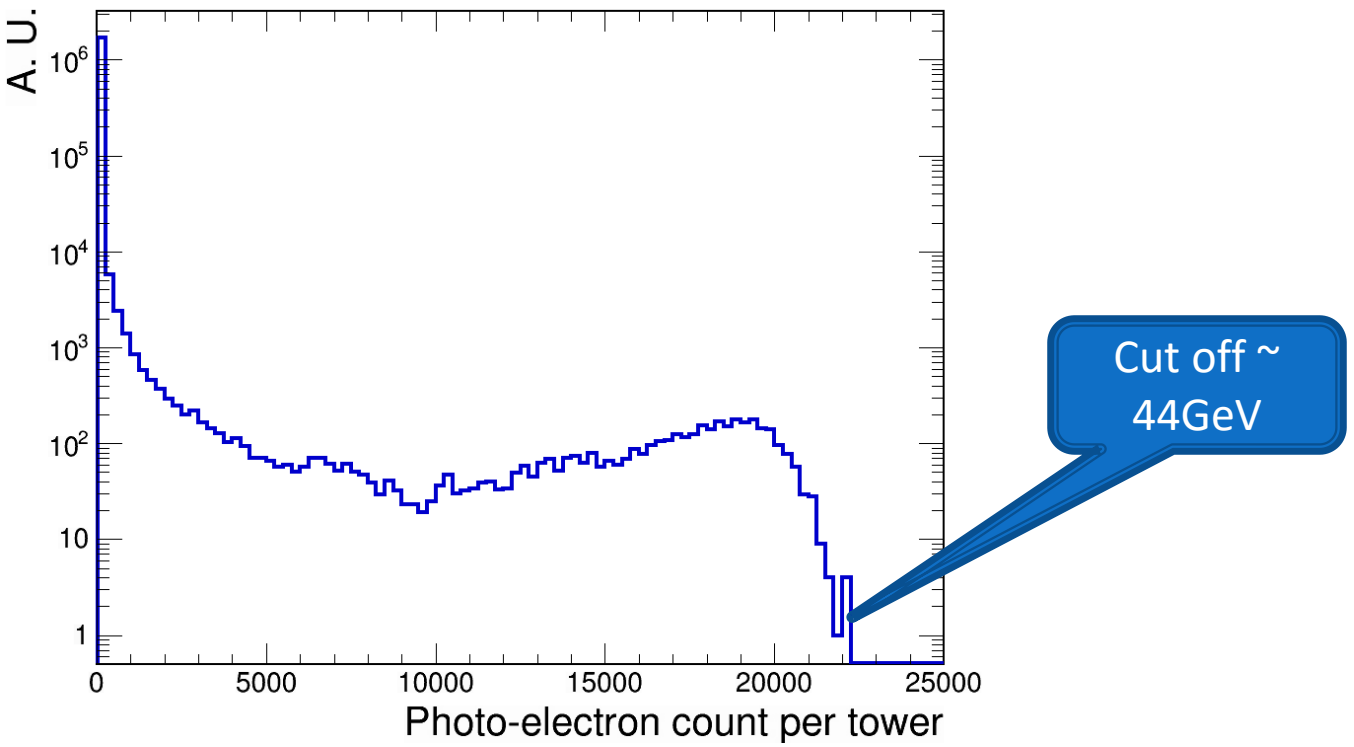
sPHENIX full detector single photon simulation



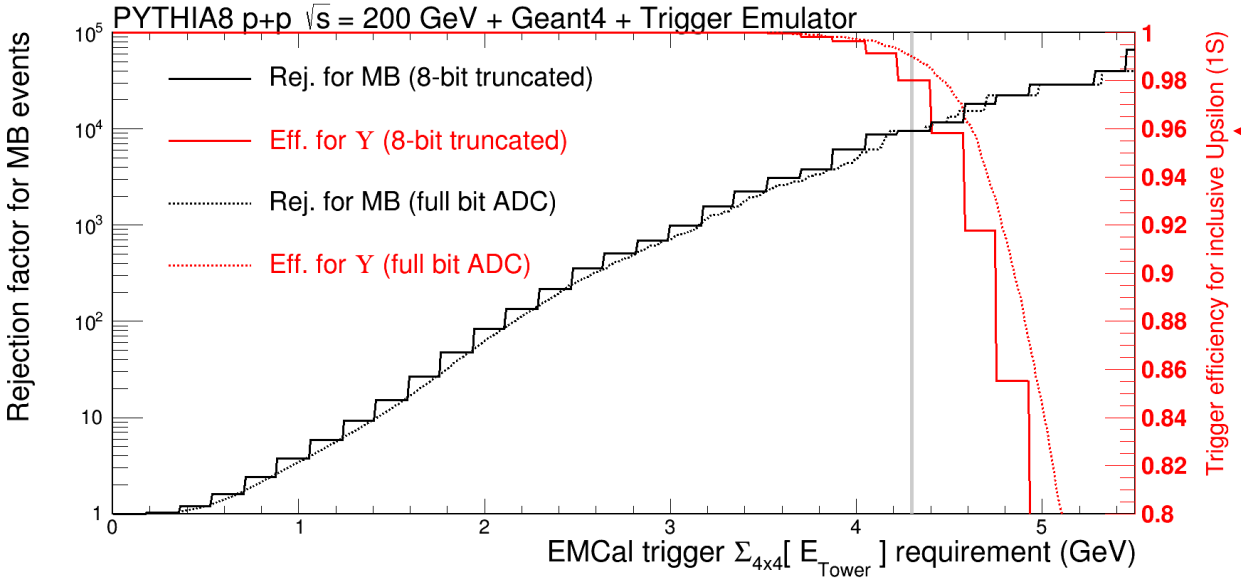
- Photon performance is similar with full detector (+10% X0 SVX before it)

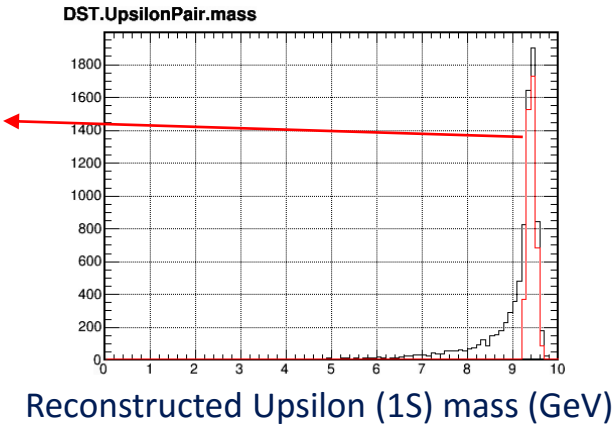
Dynamic range plot

50 GeV photon shower in 2D-projective SPACAL, all eta ranges
Plot photon observed per tower per event,
max ~ 22k photon/tower, pedestal σ~8 photon, range ~ 12bit (max/pedestal 1 σ)



Trigger efficiency – 2D SPACAL





Upsilon events required |eta_e|<1, reconstructed |mass – 9.6GeV| < 2 sigma

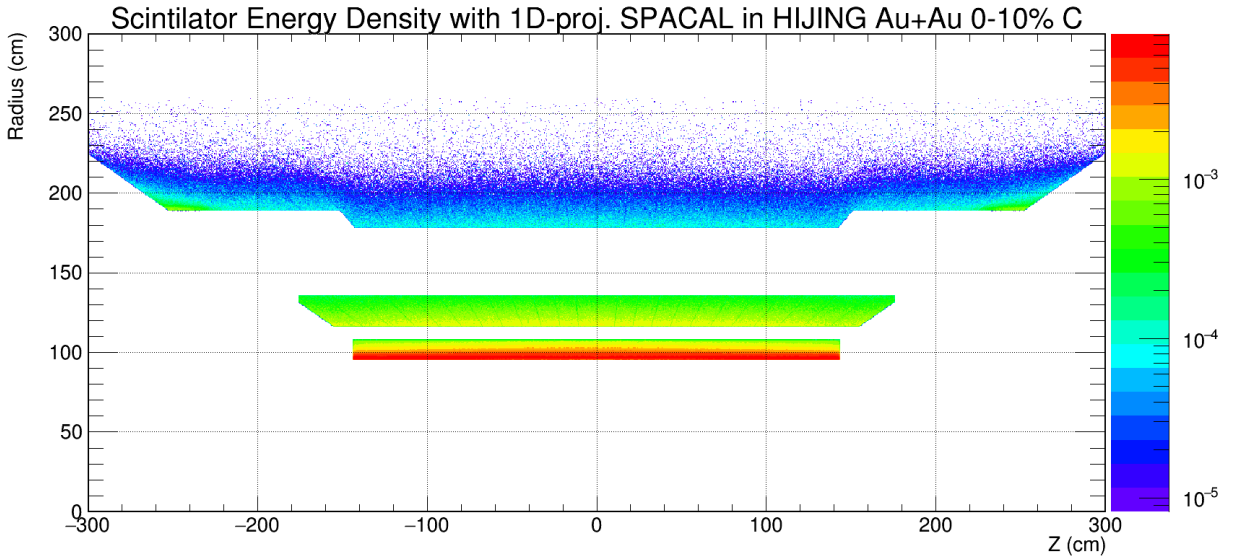
Result: ~10e4 rejection at ~98% efficiency

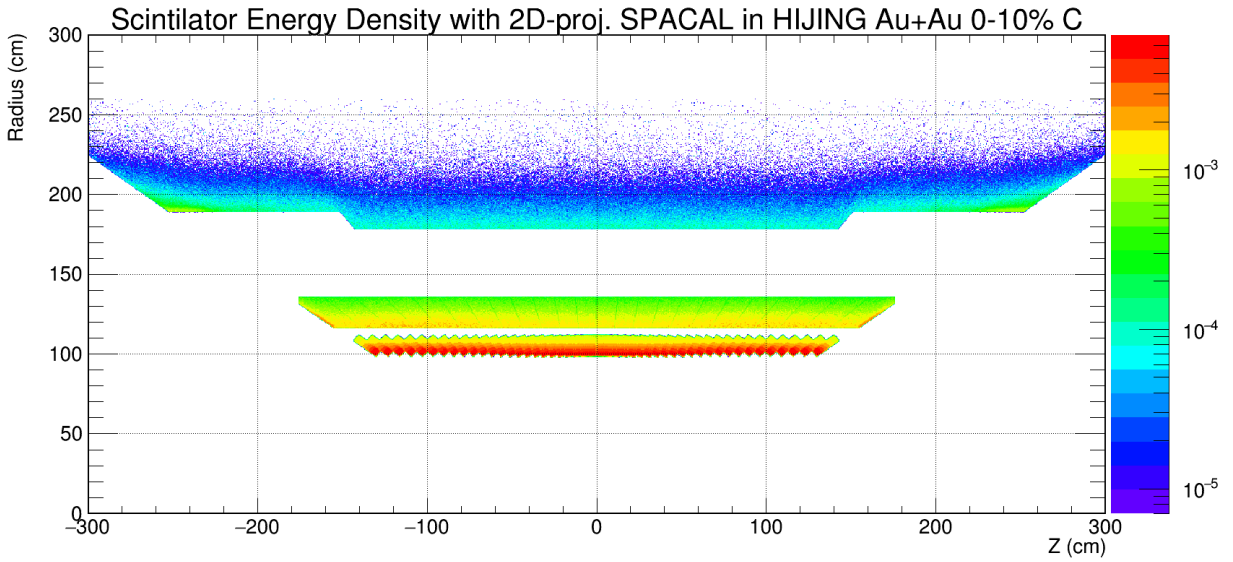
- Tail of Upsilon mass peak excluded for avoiding radiated photon, which are triggered with noticeably lower eff.
- Assumed trigger sum all combination of 4x4 towers, rather than sum of 2x2 → 4x4
- Realistic trigger would use reduced ADC bits, e.g. 8-bit. Performance did not significantly changed.
- 2D SPACAL showed. 1D SPACAL required larger cluster at the forward region

Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe/32MeV), Graph Clusterizer

Occupancy in Hijing

- Volumetric energy density shown



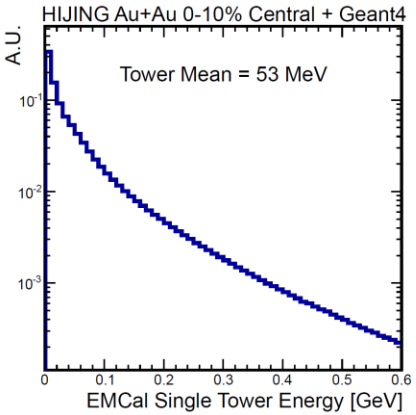


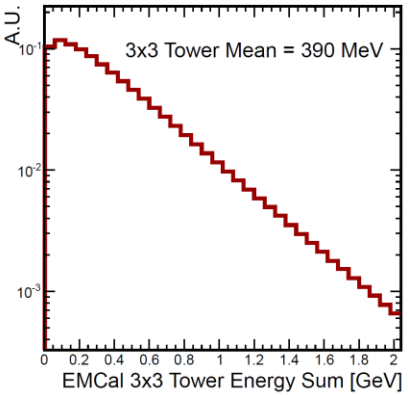
Occupancy – 0-10% Hijing

Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe/32MeV), Graph Clusterizer

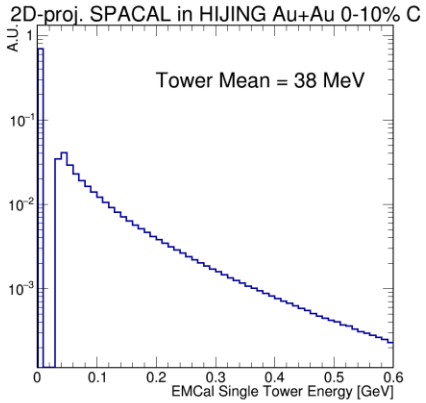
- Note the zero-suppression at 32 MeV.

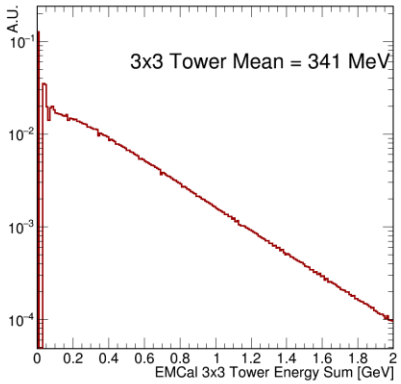
Scientific review (no digitalization, 1D proj.)

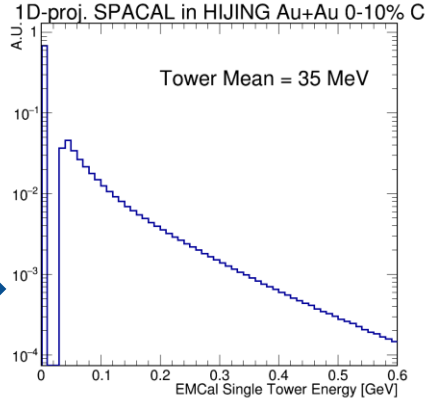


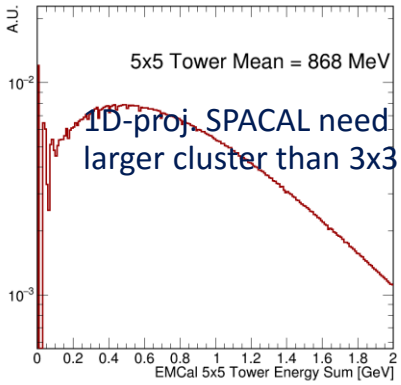


Realistic tower Digitalization





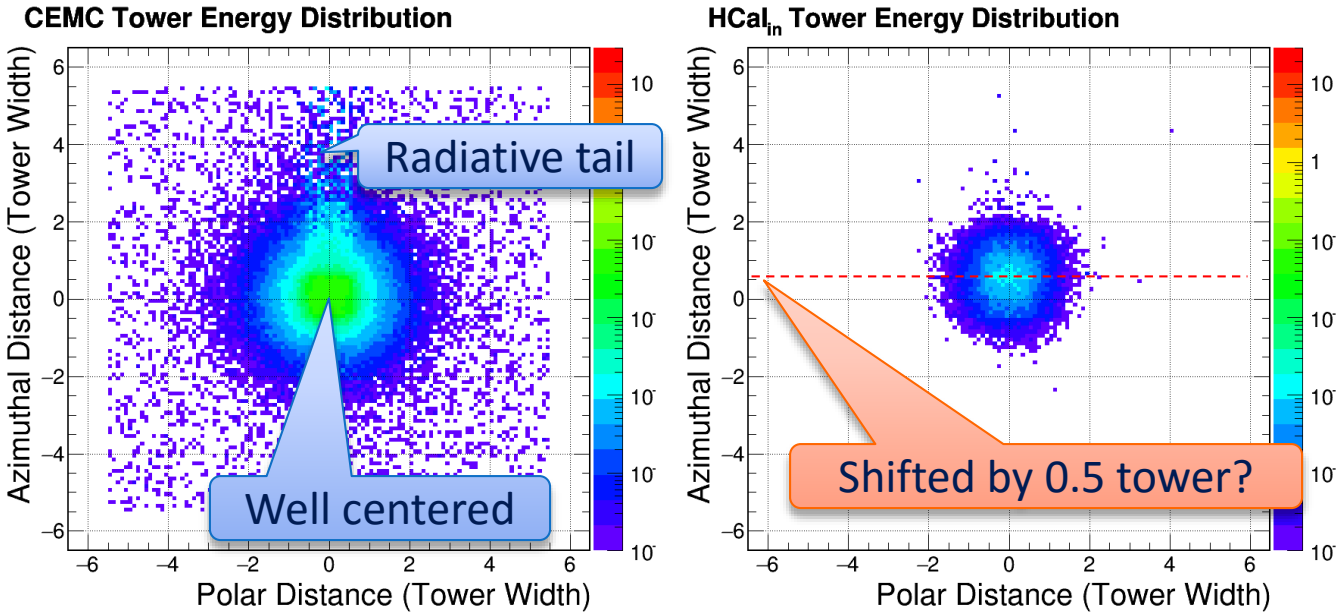




1D-proj. SPACAL need larger cluster than 3x3

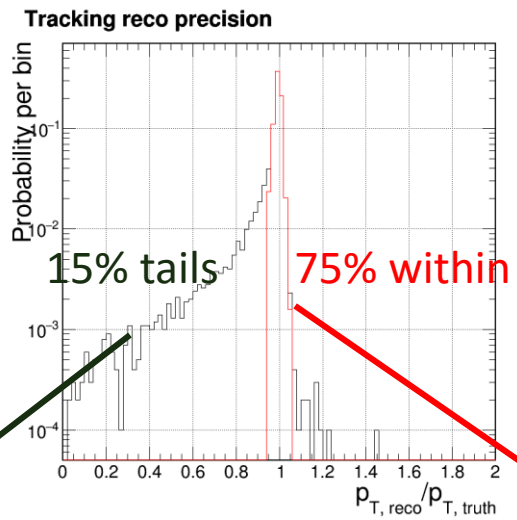
Track projection checks

- In discussion about current problem:
  - https://github.com/sPHENIX-Collaboration/coresoftware/pull/69
  - One quick solution suggested
- Result plot:
  8GeV electron track projection to 2D projective SPACAL



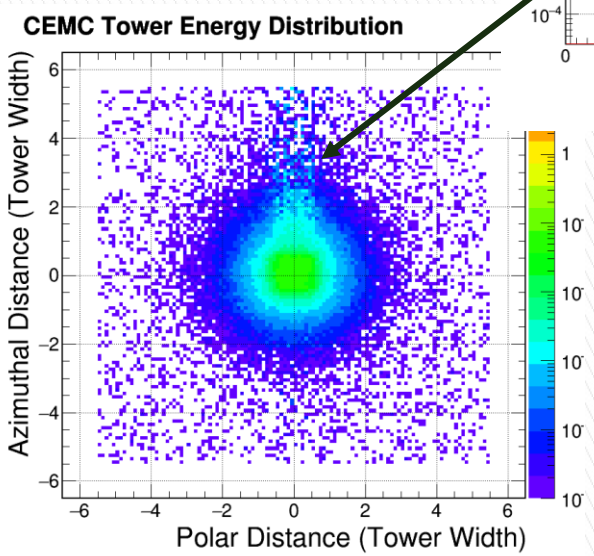
Track projection checks – Removing radiative tails

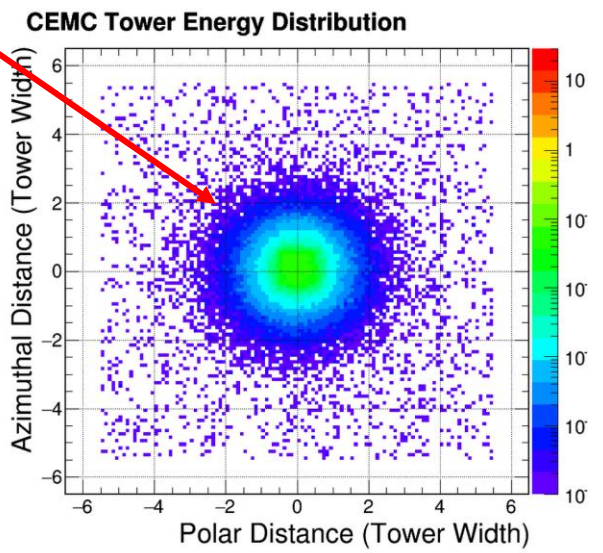
Full sPHENIX
Single electron + Geant4
+ Digitalization + Tracking



15% tails

75% within +/-5%



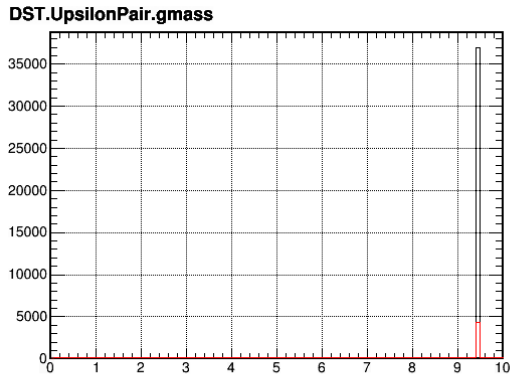


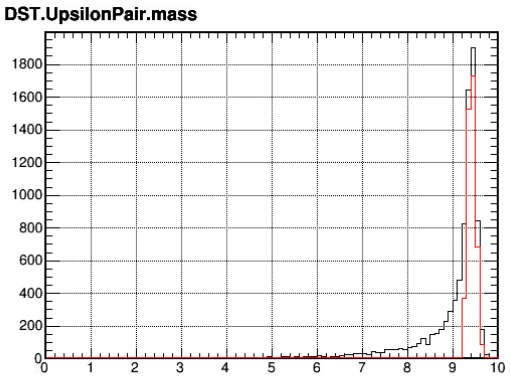
All reconstructed tracks

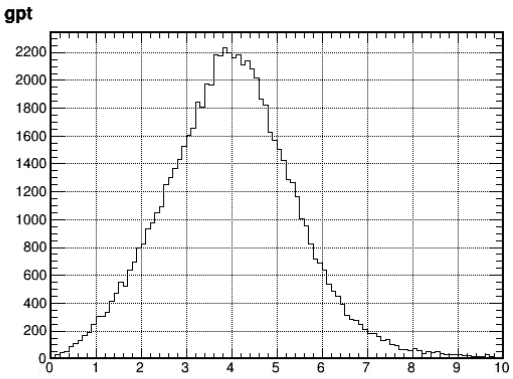
Track with pT reco within 5% of truth (sample for eID ana.)

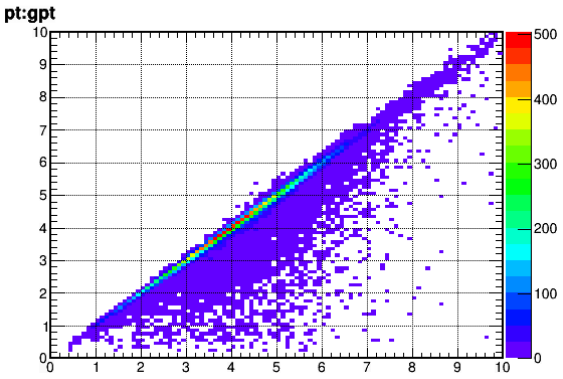
Extra information

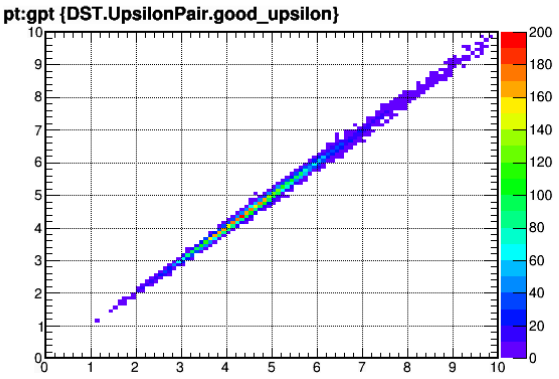
Upsilon simulation and selection







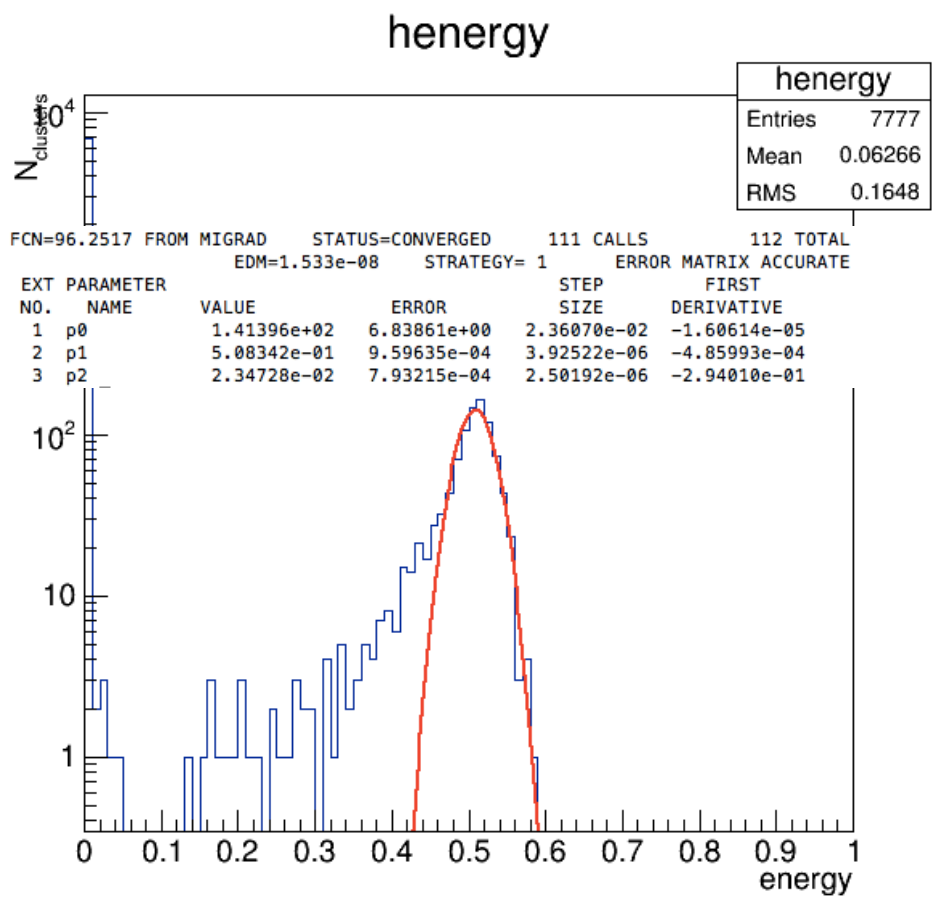


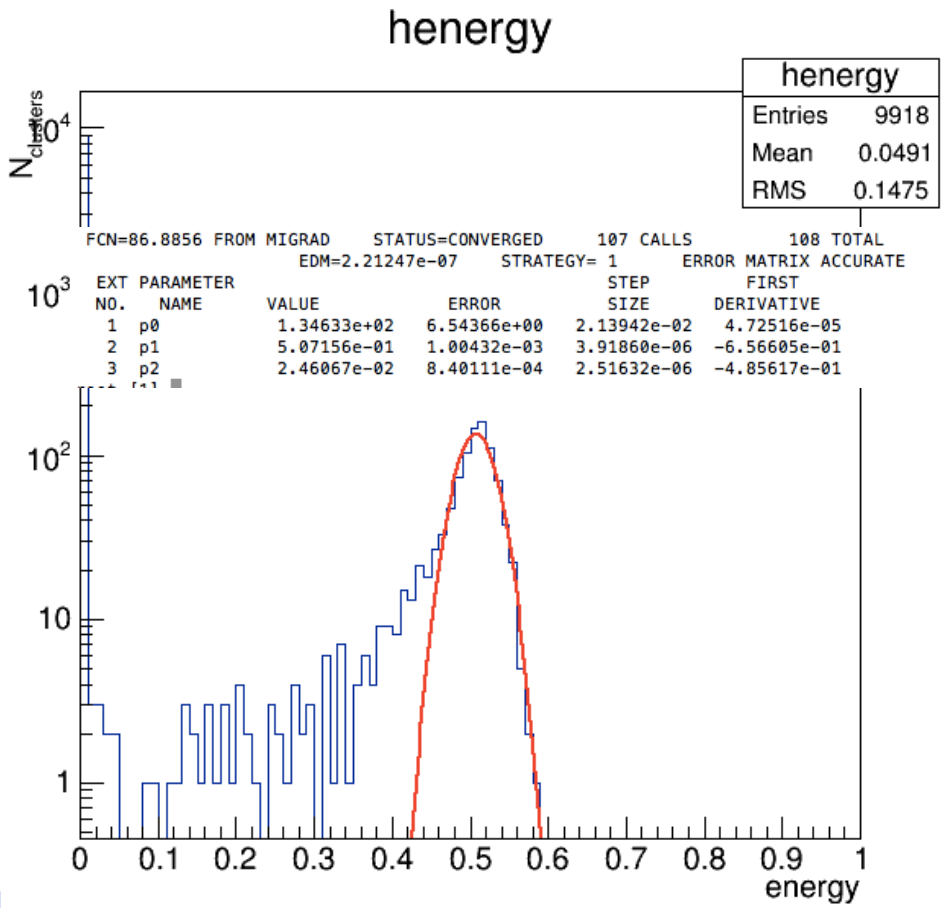


Photon resolution [Megan and Stefan]

- PHENIX Clusterizer from Sasha B. survived PHENIX->sPHENIX migration.
  - Promising use of the PHENIX Clusterizer in HI embedded events
- Fit with Gaus
- [0]*exp(-0.5*((x-[1])/[2])**2)

Plots from Megan Connors (GSU)

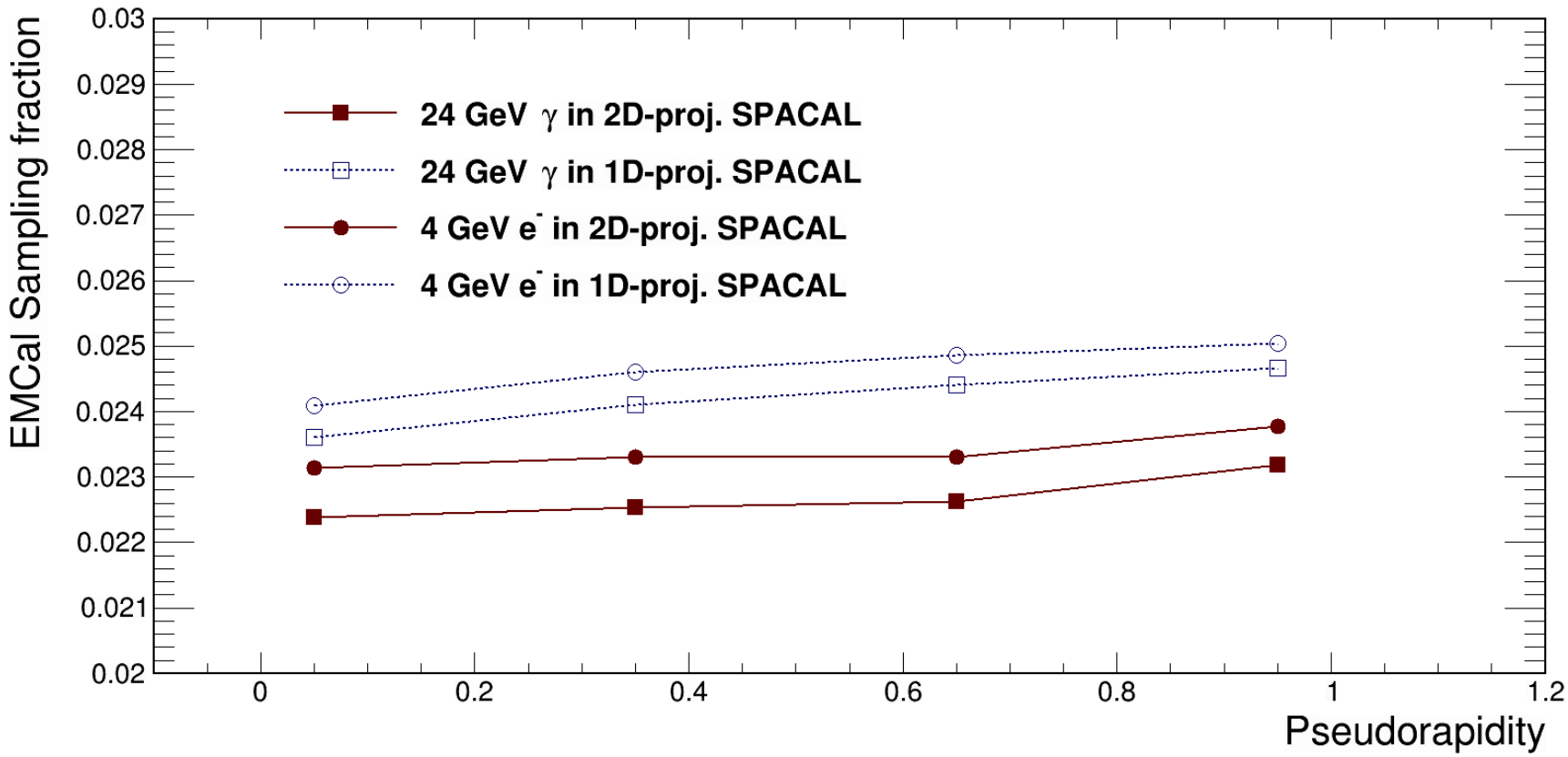




Older Pro1.Beta3 plots

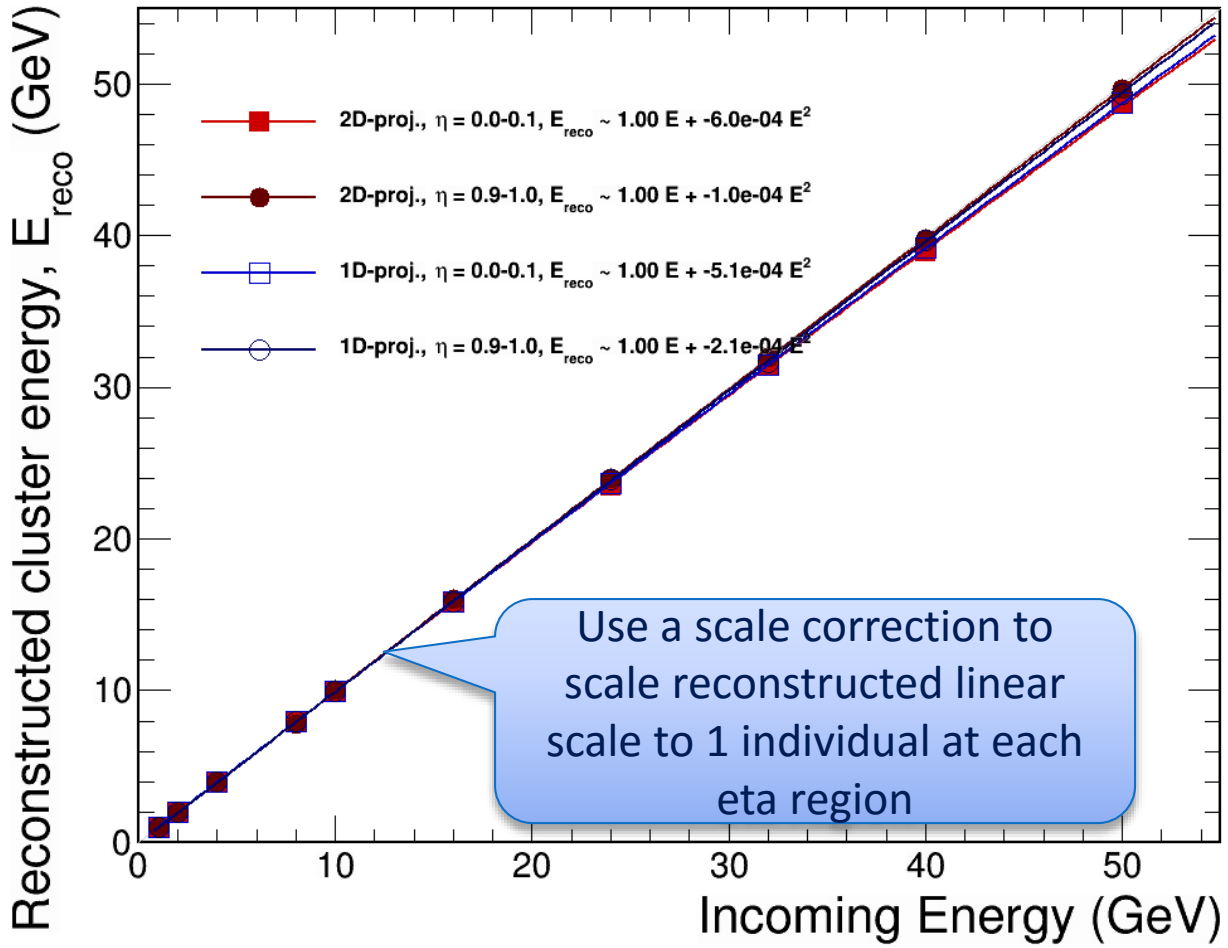
»

Sampling Fraction



/direct/phenix+sim02/phnxreco/ePHENIX/jinhuang/sPHENIX_work/single_particle/DrawEcal_DrawSF.pdf

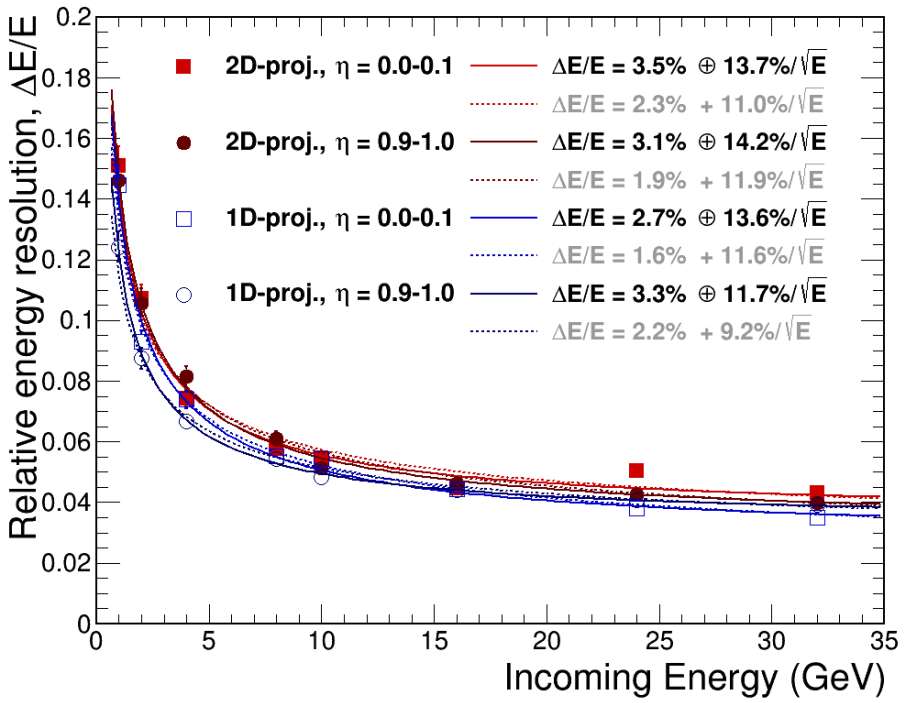
Linearality – double checking



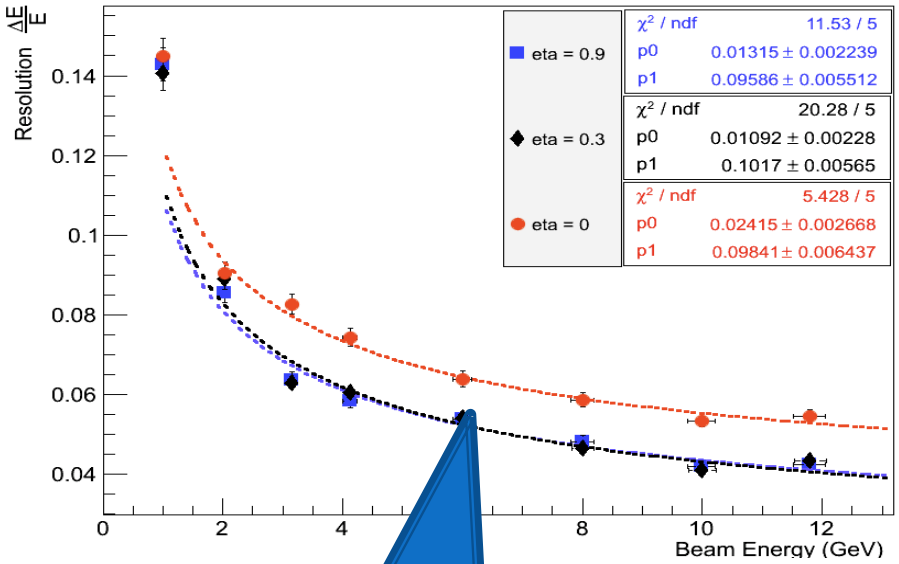
Energy resolution
Simulated with single photons

Full detector Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe), Graph clusterizer

sPHENIX full detector single photon simulation



EIC RD1 study
FermiLab beam tests



Courtesy: A.Kiselev (BNL)
DIS2014

Used [1] + [2]/sqrt(E) in fit instead of sqrt sum??

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